SPARK

REPORT

STRATEGIC
PLANNING
FOR
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RESEARCH
AND
KNOWLEDGE

Science
Council of
British
Columbia

MINING, MINERALS AND METALS

SECTOR COMMITTEE PLANNING REPORT

PREPARED FOR

THE SCIENCE COUNCIL OF BRITISH COLUMBIA

MARCH 1988

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I EXECUTIVE SUMMARY

The B.C. mining, minerals and metals industry has been and will continue to be a major part of the B.C. economy and one of the key provincial players in regional development and exports.

The industry will require a growing focus on science and technology in order to remain competitive and to develop new and innovative products in the face of increasing competition from developing countries. Companies in this sector generally have not placed a high priority on basic research and development. A substantial amount of site specific feasibility and ongoing development work that is undertaken could be classed as applied research. Many existing research centres, provincial and national, have capacity available that can be directed towards an increased, minerals-related R&D effort in this province.

In order to promote the urgency and benefits of increased R and D in the B.C. mining, minerals and metals industry, attention first must be on providing B.C. companies with a focal point for R&D in the province. An R&D coordinator must be funded who is cognizant of the workings of both the industry and research organizations. His aims will be to:

- identify the R&D needs of the B.C. mining, minerals and metals industry;
- identify research organizations that can satisfy those needs;
- develop the necessary funding;
- bring together those groups who can most effectively interact relative to specific R&D needs;

- provide a network of R&D information to B.C. companies and research centres;
- coordinate with other research-related organizations of interest to the B.C. minerals industry (e.g. MITEC, CANMET and the Coal Association of Canada);
- assist with technology transfer.

Funds must be directed to R&D with the potential of benefitting the B.C. mining, minerals and metals industry. About twice the present level of funding will bring us to the national average.

Two proven, successful means of promoting research focussed on industry's problems are through the establishment of

1) industrial research chairs affiliated with the universities, and
2) centres for advanced technology.

Proposals for both types, relating to the B.C. mining, minerals and metals industry, are being prepared at the present time and will require input and financial support.

II INTRODUCTION

The Science Council of British Columbia established a series of sectoral planning committees in early September 1987, based on its already existing AGAR grant committees, to identify opportunities for improving the application of science and technology to the economy of B.C. These committees comprise representatives of industry, universities and colleges, research institutions and government and are to develop specific sectoral plans for the application of science and technology. The recommendations of each committee will then be reviewed and priorities will be established by the Science Council and integrated into overall plans for science and technology by the Premier's Advisory Council on Science and Technology and by the provincial government.

The sectoral plans are aimed at identifying key strengths and weaknesses in order to make broad recommendations. Detailed investigations of specific opportunities or resolutions of problems identified will occur once priorities have been established.

The Mining, Minerals and Metals Planning Committee has the objective to enhance research and development in this industry in order to improve the economic benefits of this sector to the province. For the purpose of this report, the industry has been taken to include:

- mineral exploration
- mining
- minerals processing
- metals and materials processing

Research and development in the service and support industries, including transportation and equipment suppliers is also viewed as crucial to the industry.

The following were members of the Mining, Minerals and Metals Sector Planning Committee and their professional affiliations are:

Keith Brimacombe	U.B.C. Centre for Metallurgical Process Engineering
Bruce Hawbolt	U.B.C. Dept. of Metals and Materials Engineering
Brian Parrott	Mining Association of B.C.
George Poling (Council Liaison Member)	U.B.C. Dept. of Mining and Mineral Process Engineering
Cory Sibbald	Teck Corporation
Al Sinclair	U.B.C. Dept. of Geological Sciences

Approach Followed

The committee met to discuss their views of R&D in B.C. They solicited input by letter and telephone from a wide cross section of the B.C. mining, minerals and metals community, discussed the situation with representatives of national minerals organizations (CANMET, MITEC, Coal Association of Canada) and referred to recent reports on the subject of R&D in the B.C. minerals and metals industry e.g.

- "Mining Research and Development Survey" - Bapty Research Limited
- "Perspective on the Mining Industry in B.C." - Office of Federal Coordinator
  - J.P. Cooney
  - F. Eichgruen
- "Innovation in the Mineral Industry: Opportunities and Strategies for Canada" - CRS
  - M.J. Wojciechowski
  - P.R. Richardson

III BACKGROUND

The Mining, Minerals and Metals Sector addressed by this committee is described here to provide background for the discussion of the role of science and technology.

The B.C. Mining, Minerals and Metals Industry

This industry includes the exploration sector, mining and mineral processing and the metal processors. The exploration sector is broadly based, both geographically and in its search for a wide variety of minerals. The focus recently has been largely on precious metals, however, increasing attention is being paid to industrial minerals. The mineral producing sector includes those mines, quarries, and placer operations extracting mineral products. The metals processing sector includes the smelter and refinery industry which further processes minerals into refined metals and has increasing involvement with the production of advanced industrial materials. British Columbia has two major smelter/refinery operations.

A. EXPLORATION

The outstanding success of mineral explorationists in B.C. during the past century has provided the ore reserves upon which the mineral industries of the province are based. Mineral production has been obtained from many types of deposits, some world class in production, representing a wide range of geological environments. The province is known particularly for its large tonnage, low grade porphyry copper-molybdenum deposits and the giant

Sullivan lead-zinc-silver deposit. In recent years, exploration efforts have been directed to polymetallic, massive sulphide deposits and other types of precious metal-bearing deposits, with remarkable results.

The long history of success in mineral exploration has made Vancouver a world class centre of expertise; a large service industry of geological and engineering consultants and service contractors has developed with interests that spread far beyond provincial boundaries. Nearly 1,000 professional earth scientists are employed in the exploration sector with perhaps 3 times that number as support staff. Expenditures on mineral exploration in B.C. in 1987 likely exceeded $100 million. One can only guess at the additional large amount of funds that flowed into the province for the exploration work performed outside the province by local consultants and service contractors.

The B.C. and Yukon Chamber of Mines lists more than 70 known deposits in the province with potential for future production. Twenty-seven proposals for new mines were submitted to the provincial Mine Development Review Process in 1987. This clearly attests to the high productivity of the exploration and mine design sectors and the evidence of a reserve base that will provide long term viability to the mineral industry.

B. MINE PRODUCTION

1. Coal

The coal industry accounts for nearly 50% of the minerals industry's gross sales and provides direct employment for some 6,000 people. Coal production is concentrated in 7 large mines in two centres in the Rocky Mountains, in southeastern B.C. and in northeastern B.C. There is a

medium-sized open pit coal mine on Vancouver Island slowly developing as market conditions allow. There is a potential large new anthracite coal mine located in northwest B.C. and significant potential reserves exist throughout the province.

According to the Ministry of Energy Mines & Petroleum Reources, coal production in 1987 reached 22.14 million tonnes. Of the total production, an estimated 83% was metallurgical coal used in the steel making process and the balance was thermal or steaming coal. British Columbia's largest customer is Japan which purchases 72% of all metallurgical coal sold and 25% of all thermal coal sold. British Columbia accounts for 78% of Canadian coal exports. The value of coal production in B.C. in 1986 was $934.5M and in 1987, $859.7M.

2. Copper

Large scale copper development in B.C. began in earnest in the 1950's with the development of large, low grade porphyry copper deposits. These mines were economic through the availability of abundant low cost power. Today, there are 10 mines producing copper. British Columbia copper is mined and processed to the concentrate stage. Concentrate is then exported for further processing into metal.

In 1987, B.C. copper mines produced over 1 million tonnes of copper concentrates estimated to contain 348,246 tonnes of copper metal. The value of this production is estimated at $745M ($629M in 1986). These concentrates are exported primarily to Japan. British Columbia's copper production is the highest in Canada and accounts for approximately 40-45% of Canadian output.

3. Lead/Zinc

Lead and zinc production in B.C. historically has centred around Cominco's Sullivan mine at Kimberley feeding the lead/zinc smelter at Trail. In addition, a polymetallic mine on Vancouver Island produces zinc and lead as do several smaller operations, most of which ship concentrate to Trail for smelting.

In 1987, mine production of zinc totalled 118,656 tonnes valued at $98M. In 1986, 137,587 tonnes valued at $138M were produced. Lead production was 67,210 tonnes in 1987 valued at $46.9M compared with 91,784 tonnes valued at $38.2M in 1986. The bulk of this production is smelted and refined into metal at Cominco's Trail operations. British Columbia is Canada's largest lead producer with about 40% of the country's production.

4. Molybdenum

Molybdenum production in B.C. has declined dramatically in recent years as a result of falling prices. In 1985, there were no primary producers operating, however, one (Endako) reopened in 1986. In 1986, production was 11,574 tonnes valued at $92.8M and in 1987, production increased slightly to 11,581 tonnes and was valued at $92.6M. British Columbia is Canada's major producer of molybdenum accounting for nearly 97% of the country's total.

5. Precious Metals

Gold and silver production in B.C. fluctuates with precious metal prices and the production of base metals. Most gold is currently produced as a by- or co-product from copper or polymetallic mines. There are, however, a number of new gold mines or placer operations that add significantly to B.C.

gold production. Production of gold in 1987 totalled 11.9 million grams valued at $231.6M. This was up from 9.0 million grams valued at $155.0M in 1986. British Columbia's gold production is about 8% of Canada's total.

Silver is produced at several mines in the province, the largest producer being Equity Silver at Houston. Many other mines produce silver as a by-product and in 1987 total production was estimated to have been 397 million grams valued at $125.7M. Production of 395.8 million grams in 1986 was valued at $94.6 million. British Columbia's silver production is approximately 30% of Canada's total.

6. Industrial Minerals and Structural/Materials

British Columbia produced an estimated 95,300 tonnes of asbestos in 1987 representing about 12.5% of total Canadian production. Other industrial minerals produced in B.C. include magnesite, barite, gypsum, jade and diatomite. The industry also produces structural materials such as sand and gravel, clay, building stone and limestone. The value of industrial minerals production in 1986 was $51.8M. In 1987, it increased to $60.9M.

C. METALS PROCESSORS

1. Aluminum

Alcan operates an aluminum smelter in Kitimat utilizing low cost power produced at its Kemano hydro power plant. Bauxite, the primary ore from which aluminum is made, is not indigenous to B.C. and therefore the mineral is imported to Kitimat in the form of alumina for smelting. Alcan's annual production capacity at Kitimat totals some 268,000 tonnes of metal.

2. Lead/Zinc

Cominco's integrated smelter and refinery complex at Trail produces a wide range of metals, principally, refined zinc, lead, silver and gold. In 1985, the metallurgical complex produced 262,800 tonnes of zinc metal, 120,000 tonnes of lead metal, 304,000 kilograms of silver and 960 kilograms of gold. The zinc metal output is the largest in Canada representing nearly 40% of total refined production. Lead production is also the highest in Canada.

3. Steel

Western Canada Steel in Vancouver melts steel scrap and casts and rolls billets to form structural reinforcing rod, bars angles, etc. Their capacity is approximately 200,000 tonnes/year with an estimated value of $60 million.

D. VALUE OF PRODUCTION

The total value of production of the materials discussed above was nearly $2.2 billion in 1986 and nearly $2.3 billion in 1987. Coal represents approximately 45% of the total. In terms of metals, B.C.'s value of production ranked third in Canada in 1985 being approximately 12.5% of the country's total.

Value of Mineral Production
in British Columbia

1983 - 1987
$millions

	1983	1984	1985	1986	1987*
Metals					
Copper	$ 559.6	$ 517.8	$ 579.7	$ 629.5	$ 744.7
Gold	130.9	118.1	94.5	155.0	231.6
Iron Concentrates	13.0	6.6	3.8	2.2	2.3
Lead	48.8	37.9	41.7	38.2	46.9
Molybdenum	87.6	113.8	72.5	92.8	92.6
Silver	179.9	121.4	93.0	94.6	125.7
Zinc	79.6	115.2	112.7	138.0	98.0
Other	4.6	6.1	8.2	6.3	4.4
Total Metals	$ 1,104.0	$ 1,036.9	$ 1,006.1	$ 1,156.6	$ 1,346.3
Industrial Minerals	64.6	87.5	68.1	51.8	60.9
Coal	555.8	1,007.5	1,028.3	934.5	859.7
Total	$ 1,724.4	$ 2,131.9	$ 2,102.5	$ 2,142.9	$ 2,266.9

*Estimates

Source: Energy, Mines and Petroleum Resources.

E. EMPLOYMENT

Employment in the mining and metals industry is down from the historically high levels achieved in the 1980-81 period yet total direct employment in this entire sector is estimated to be in the order of 28,000. Assuming a modest multiplier effect of 1.5 indirect jobs for every direct job, an estimated 70,000 people rely on the mining, minerals and metals industry for their livelihood.

F. REGIONAL DEVELOPMENT

Mining has continued to be the catalyst for developing new regions of the province. The development of the Cassair mine in northwest B.C. led to the creation of a new town and the development of Highway 37 which has provided a

second, more direct road link to the Yukon and Alaska and good access to tidewater at Stewart, B.C. via Highway 37A. The re-development of the coal industry in south-eastern B.C. in the early 1970's, led to the creation of new communities and improved infrastructure.

The $2.5 billion investment in northeastern B.C. by both government and industry created two new coal mines and led to the development of much needed infrastructure and employment. Although the northeast is the most spectacular recent example of mining working to enhance regional development, there is an ongoing injection of capital by the industry leading to direct and indirect employment in all regions of the province. The ten year total exploration, development and capital expenditures by the mining industry in these economic regions is shown below.

Exploration, Development and Capital Expenditures
by Economic Region

1977 - 1986
($millions)

East Kootenay	$ 1,053
Central Kootenay	439
Okanagan-Boundary	61
Lillooet-Thompson	487
Lower Mainland	66
Vancouver Island & Coast	246
Cariboo-Fort George	326
Peace River Liard	1,069
Skeena-Stikine	360
Total	$ 4,107

Source: Price Waterhouse - M.A.B.C. survey participants only.

In addition to these expenditures already incurred, there are currently 27 proposed new mines under review, distributed throughout the province.

G. CONTRIBUTION TO THE ECONOMY

1. Gross Domestic Product

A measure of the significance of an industry to the economy, is the industry's contribution to the Gross Domestic Product. On this basis, the mining, minerals and metals industry is an essential component of a healthy B.C. economy. Over the last 10 years, this industrial activity, including the extraction and smelting/refining of metals in B.C. has accounted for, on average, about 15% of all goods produced in the province, second only to the forest-related industry.

2. B.C. Exports and the Role of Mining/Metallurgy

Minerals and metals exports account for nearly 26% of all B.C. exports. This compares with forest products which account for 51% of exports and energy products which account for 8% of exports.

The mining, minerals and metals industry in B.C. is significantly more export oriented than other goods producing sectors. Ninety percent of all minerals and metals production in B.C. is exported as opposed to 73% for forest products. As a result, it is essential that the industry keep pace with the increasingly competitive international market place.

H. FUTURE TRENDS FOR THE INDUSTRY

There are differing views on the future prospects for the minerals industry in B.C. One view sees a cyclical upturn in the worldwide demand for metals with increased competition from lower cost producers. This will force the industry into new productivity and cost improvements with heavy reliance on the further use of technology as other cost saving approaches are exhausted. A second scenario is that materials technology is progressing to the point that advanced industrial materials are replacing a significant component of ferrous and base metal products. Thus, extraction of ferrous and base metals will decline in importance and an increased emphasis will be placed on industrial minerals and structural materials that form the resource for many of the advanced industrial materials. Either of these two scenarios will place the mineral industry as it now exists under substantial pressure to change. In the one case, we must improve our productivity of existing mines; in the second, we must apply new and improved technology to new types of resources. It seems probable that some elements of both scenarios might prevail.

The mining, minerals and metals industry in B.C. is now, and will continue to be, under increasing attack from the emerging industries in the developing countries. To face this competition effectively, the B.C. industry must continue to place reliance on technological improvements to retain its competitiveness and to develop new and improved products.

A further continuation of the productivity improvements achieved in the past few years will require increasing attention to technological development since additional labour productivity gains are now limited.

IV SCIENCE AND TECHNOLOGY IN B.C.'S MINERALS INDUSTRY

OVERVIEW

There have been significant technological advances in all sectors of the mining industry.

Exploration

In the exploration field, technological advances have occurred in geology, geochemistry and geophysics. Geochemical exploration was pioneered in the province and many techniques developed here contributed to making Vancouver a world-renowned centre for research and development as well as being a major analytical service centre. Geological research in the province has provided the geological data base on which the provincial exploration sector is dependent. In addition, there have been important contributions to data analysis techniques and the development of site-specific geological models for use by explorationists. Geophysical research applied to mineral exploration has been limited in B.C. in the past but recent contributions in the development of a fluxgate magnetometer, applications of inversion theory and a new geophysical survey approach utilizing the piezoelectric property of quartz are at the leading edge of applied research.

Mining

Open-pit walls have been stabilized or steepened by the use of special dewatering techniques; even vacuum assisting is used. Several large-scale open pit mines have converted to in-pit crushing and conveying to replace off-road truck transport. Hydraulic mining technologies have been developed locally for

underground coal mining. Some molybdenite concentrates have been made marketable only by the use of special leach-purification techniques developed locally. Environmental impacts have been minimized through advances in world leading mine waste and tailing disposal technologies. Leading process control technologies are marketed worldwide. British Columbia companies are world-leaders in developing bio-leaching of both copper and refactory gold ores.

Metals

In this sector, technological developments include Cominco's development of the zinc pressure leach process, their production of electronic-grade gallium arsenide single crystals and Teck's development of the moly-lithium battery.

EXPENDITURES ON R&D

The expenditures on research and development within the B.C. minerals sector is estimated to be between 0.5% and 0.8% of the total G.D.P. of the sector. By comparison, research and development expenditures in the mining, minerals and metals sector for Canada overall amount to 1.3% of G.D.P. of the industry. This though is, in part, due to the concentration of industry research centres in central Canada which therefore may bias these indicators. These percentages mirror almost exactly the overall provincial and national averages of R&D as a percentage of G.D.P. and are significantly lower than the percentages of the leading industrial nations which are consistently in the range of 2.0%-3.0% of GDP.

The federal government spends 65%-70% of the total science and technology dollars. The B.C. government spends very limited amounts through Science Council AGAR grants and scholarships.

Mineral Development Agreement (MDA)

Through this federal/provincial agreement, a limited amount of funding has been provided for a variety of research projects, the total cost of which is estimated at $560,000 over the past three years. Through this MDA, governments have provided funding of $166,000, the balance of $394,000 coming from industry. This activity, although contributing significantly to the B.C. R&D activity, is very low when compared to other provincial MDA's (i.e. Manitoba's MDA allocated $4.5 million to R&D over a 5 year period).

MINERAL-RELATED RESEARCH ACTIVITIES IN B.C.

Mineral-related research activities in British Columbia are conducted in a number of widely dispersed centres throughout the province but most are concentrated in the Lower Mainland and Victoria. A few of the more important sites are described below.

Industrial Laboratories

Research conducted at most private laboratories is proprietary information that generally is not publicly available. Most studies are directed to topics of immediate economic concern.

1. Cominco Technical Research Centre

The Cominco Technical Research Centre at Trail is an excellent example of an industrial laboratory involved in mission-oriented research. This laboratory coordinates in-house investigations for Cominco Ltd. and affiliated companies as well as undertaking private contracts for other organizations. Principal strengths are in the areas of conventional mineral dressing, solvent extraction metallurgy, hydrometallurgy of gold, lead, zinc and phosphate ores and concentrates, and the roasting of sulphide ores.

2. Bacon, Donaldson & Associates

This private laboratory and consulting firm is currently researching the "arseno process" for recovering gold from refractory ores.

3. Coastech Research

This organization is active in researching bio-leaching processes and acid mine drainage prediction and prevention.

4. Giant Bay Resources

This company is actively researching bio-leaching techniques.

5. Gibraltar Mines Ltd.

This mine has recently installed a solvent extraction plant to recover copper from bio-leached dumps. Technologies to extend leaching through winters are being developed.

6. Placer-Dome

This laboratory has developed improved technologies for selective absorption of gold onto activated charcoals. They are also investigating the potential use of vibro-accoustics in accelerating leaching rates.

7. Column-Flotation Cells

Several B.C. concentrators have developed an innovative technology of column-flotation. This new technology is currently displacing conventional cells throughout the world.

Consulting Engineers

British Columbia has many world class consulting engineering organizations with expertise in exploration, mining, minerals processing, minerals bulk handling and metals processing. Several of these companies are developing and marketing special software packages for enhancing exploration, mine-mill design and environmental protection.

Operational Innovation

Innovative methods are investigated and implemented at virtually every mine-site in B.C. These innovations occur primarily to improve productivity. In many cases, these improvements are not recognized and reported as research and development.

B.C. Research

B.C. Research is an independent organization that conducts research and development under contract to sponsors in industry and government. Of

particular interest to the R&D needs of the B.C. mining, minerals and metals industry is expertise in the fields of CNG engines, aquatic toxicology, process control bio-leaching, precious metals recovery, hydrometallurgy and conventional mineral dressing techniques. Annual expenditures in all fields total about $8 million with about 40% derived from industry.

The University of British Columbia

Research related to the mineral industry is spread principally among several departments in the Faculties of Science and Applied Science. Each department represents a separate, independent centre and there is relatively little interaction among groups.

The Department of Geological Sciences has a research budget of $1.3 million of which one quarter is directed towards applied research related to the mineral industry, a greater proportion than in most other comparable departments. The remainder relates to basic research, but even this provides a significant contribution to the data base that is so fundamental to mineral exploration. The department houses a wide range of analytical, chemical, experimental, library and computer facilities not readily available at most other research centres in B.C. The department includes 19 professors, about 30 technical and support staff and 50 graduate students. Funding is derived mainly from NSERC with lesser but important contributions from the Geological Survey of Canada, the Science Council of B.C., the B.C. Ministry of Energy, Mines and Petroleum Resources (Geological Survey Division) and Industry.

The Department of Geophysics and Astronomy has 9 faculty members who work in various fields of geophysics. They are supplemented by a research and technical support staff of 14 and a complement of about 28 graduate students. They have contributed at the forefront of seismic and electromagnetic data interpretation and have made important contributions to geophysical instrumentation and methodology. A fluxgate magnetometer designed in the department recently has been licensed for manufacture and sale. Research is progressing on use of the piezoelectric character of quartz as the basis of a new approach to geophysical exploration. Funding is almost entirely from NSERC with a small but important component from industry.

The Department of Mining and Mineral Process Engineering provides undergraduate and graduate education and research in metalliferous minerals, industrial minerals and coal. The department is recognized throughout the world as a leader in several fields of mining and process engineering. A majority of the research funding currently supporting 25 research projects comes directly from the mining industry and includes contracts with international companies. The department includes 8 faculty and 7 technicians as well as 3 office staff. Faculty in the department have won major awards recognizing excellence from the Canadian Institute of Mining and Metallurgy (in the form of Distinguished Speaker Awards); the American Institute of Mining and Metallurgy; and from UBC (4 Faculty have recently won Walter Gage - Teaching Awards). Research in the department focusses strongly on rock mechanics, mine valuation, mine ventilation, comminution, process control and optimization, coal preparation, precious metals recovery and environmental protection.

The Department of Metals and Materials Engineering has an international reputation as one of Canada's strongest research/teaching departments. Its strengths include a broad spectrum of research activities ranging from extraction to shaping, fabrication and design of metals and materials (ceramics, composites and electronic materials) and a strong interaction with North American industry. Currently thirty companies, including Cominco, Alcan, Western Canada Steel and Noranda are supporting research projects in the department. The total research budget is $2.5 million annually and the amount has been consistently increasing. The department includes 17 faculty members, 32 technical staff (80% research supported) and 40-50 graduate students. Unique to the department is a modern electron optics lab (SIM, STEM, SEM), a thermomechanical simulator, pilot plant facilities and analytical, metallographic and modern testing equipment. As a measure of the strength of the program, the department has attracted two Industrial NSERC Chairs, a new Industrial Chair in Hydrometallurgy as well as a B.C. Science and Engineering Gold Medal and a U.B.C. Killam Prize.

Within the newly created Centre for Metallurgical Process Engineering (1985) there is a focus of research activity on the analysis and design of metallurgical processes. The Centre has attracted broad industry support and recognition for its research in lead flash smelting, zinc and aluminum casting, copper converting, zinc fuming and the continuous casting of steel. A major new research thrust is the linking of steel properties to process variables to develop new processes and industrial controls. The Centre has been very successful in developing and transferring technology to the industrial sector. Computer modelling combined with extensive laboratory/industrial trials have

been the key component to this success. New research initiatives are being made in advanced materials processing such as improvements in GaAs crystal growth, plasma processing of ceramics and the fabrication of high-temperature superconductors.

Industry/University Linkages

While the expertise and facilities at the universities focussed on the mining, minerals and metals industry is extensive, they are not generally communicated throughout the B.C. industry. As a result, industry's direct utilization of some of these capabilities is limited. Significant effort is required on the part of both industry and the universities to fully utilize this resource.

Science Council of B.C.

Mining, Minerals and Metals is one of 9 sector committees of the Science Council of B.C. which provides grants through its AGAR program for applied research. It also provides scholarships for graduate students working on applied research.

National Research Activities

In addition to the B.C. activities identified above, the minerals industry in the province participates in a number of national activities involving research and development.

1. CANMET

CANMET has federally funded research activities with laboratory facilities and an annual budget of $70 million. None of these laboratories are located in B.C. and no ongoing presence presently exists in the province. However, CANMET currently proposes to locate an individual in Vancouver to communicate with B.C. industry in order for it to better utilize CANMET's services. CANMET has established a useful "Index of Mining Technology Projects" which lists information made available to CANMET on mining research and technological developments in Canada. CANMET may expand this service to include research in other aspects of the industry.

2. MITEC

This organization, associated with the Mining Association of Canada and entirely funded by industry, is providing a focussing, planning and coordinating role for research and development across Canada. To date, this effort has resulted in establishing centres of excellence outside of B.C. It would welcome complementary activities that could be focussed in this province.

CURRENT INITIATIVES RELATING TO R&D

Bapty Research Report

Bapty Research Limited submitted a report entitled "Mining Research and Development Survey" to their sponsors (BCMEMPR and MABC) in November 1987. The report, based on a sample of 6 operating mines in British Columbia, attempted to gather information on the present status of research and development by operators in the B.C. mineral industry and to gain some insight into industry's views for future direction. The essential conclusions of the survey are summarized as follows:

1. Mining R&D does not get a high priority at most operating mines in B.C.

2. Dollar investment in R&D by the B.C. mineral industry appears to be at about half the level of the industry nationally.

3. There are negligible CANMET and CANMET/MDA funds supporting R&D in British Columbia.

4. The experience of B.C. mining operations with external research has been generally negative. Goals of all involved in the research are not always the same and deadlines do not have the same importance to all participants.

5. R&D infrastructure for mining technology is viewed as "not well developed" in B.C.

6. No single, formal organization exists in the province to recommend policy, promote projects, arrange funding, coordinate activities or, in general, to advance mining R&D programs.

The Mining Association of B.C. and the Mining Suppliers, Consultants and Contractors Association of B.C.

These organizations are also currently reviewing the role of R&D in the mining, minerals and metals industry of B.C. and are focussing on the need for a focal point, with resources, who can coordinate the R&D needs and information in the province for the mining, minerals and metals industry and relate those needs to equipment suppliers/manufacturers to enable that group to assist and participate in innovation. They are currently working on plans to carry this concept to its next stage. These plans included presentations at the annual meetings of the organizations on February 26, 1988 and requests for funding to the Western Diversification Fund. They also plan to coordinate their efforts with the initiatives flowing from this Science Council planning effort. In this way, the resources of all parties involved with R&D in the province, including the provincial government, Science Council, federal government, MITEC and industry can move forward in a coordinated manner.

Coal Association of Canada

The Coal Association of Canada is presently involved, through a retained consultant, in studying the research and development activities of the coal producers, the railways and the processing industry across the country. The results of this study will be known in the next few months and need to be integrated into the plans for B.C. research and development.

Summary

While a variety of R&D activities are in place throughout the province, there is a lack of co-ordination among these activities, particularly in those areas of mutual benefit. In addition, funding levels, compared to other jurisdictions in Canada are low, given the importance of the industry in the provincial economy.

V STRATEGIC NEEDS OF R&D IN THE B.C. MINERALS INDUSTRY

Based on the current and projected near-term status of the industry and a general awareness of the level of research undertaken in the recent past, the following needs have been identified:

1. To increase the awareness of and support for R&D within the industry.

2. To implement a coordination centre concerned with R&D for the B.C. mining, minerals and metals industry. This is essential to focus effectively and efficiently R&D activities to the benefit of the mining, minerals and metals industry.

3. To increase the interaction of existing mining, minerals and metals research centres in the province, including B.C. Research and various university departments, with industry in order to strengthen the centres and localize groups of experts that can be drawn on as needed to assist in solving technical problems important to the industry.

4. To gradually increase the amount of in-house, mission-oriented research and development by the mining, minerals and metals industry and to assist in technology transfer.

5. To increase the benefit to B.C. from national R&D activities that impact on the mining, minerals and metals industry. In particular, more CANMET funds should be directed to problems of the B.C. industry and more of those funds should be spent at research centres in British Columbia.

6. To improve the research capabilities of existing mining, minerals and metals research centres in British Columbia with a variety of existing programs including:

    1) centres of advanced technology, and

    2) the establishment of government/industry, mission-oriented research chair affiliated with Universities.

VI RECOMMENDATIONS

The committee recognizes that it will be a major task to increase the amount and effectiveness of R&D in the B.C. mineral industry. Consequently, we limit ourselves to four recommendations that we feel can have a dramatic and positive impact on the expansion of mining, minerals and metals related R&D in British Columbia over the near term.

1. Establish and fund an R&D coordinator in B.C. for the B.C. mining, minerals and metals industry.
2. Support the establishment of Industry research chairs directed towards R&D in the mining, minerals and metals industry.
3. Provide an increase in resources applied to R&D in the mining, minerals and metals industry.
4. Support the establishment of centre(s) of excellence in fields related to the mining, minerals and metals industry.

1. R&D Coordinator

This position is critical to the theme of this report. The individual must be familiar with procedures and problems of the mining, minerals and metals industry and must be knowledgeable in methodologies and requirements in conducting research. The coordinator should be funded jointly by industry and government and should be located where he has easiest access to information and lines of communication. This recommendation should be coordinated with the current initiative of the Mining Suppliers and Contractors Association of B.C.

Duties of the coordinator will be to:

1) Identify the R&D needs of the B.C. mining, minerals and metals industry through forums, workshops, etc..

2) Identify research organizations that can satisfy those needs.

3) Develop the necessary funding.

4) Bring together those groups who can most effectively interact relative to specific R&D needs.

5) Provide a network of R&D information to B.C. companies and research centres.

6) Coordinate with other research-related organizations of interest to the B.C. minerals industry (e.g. MITEC, CANMET and the Coal Association of Canada).

7) Assist with technology transfer.

8) Fully investigate tax incentives and other advantages for the industry to invest in R&D.

2. Industry Supported Research Chairs

Industry supported research chairs are a remarkably effective means of directing research to specific problems as is so ably demonstrated by the Stelco-NSERC research chair in process metallurgy in the Centre for Metallurgical Process Engineering at UBC. Possibilities for industry supported chairs include geostatistics, industrial minerals, advanced industrial materials processing, surface mining and minerals processing. The committee strongly supports the concept of such chairs but recognizes that they must be implemented in response to a demand from industry if they are to be successful, if for no other reason than that a significant proportion of the funding must be provided by industry. The Science Council of B.C., through the Mines, Minerals and Metals Grant Selection Committee, should involve itself in formulating and financing appropriate research chairs in cooperation with NSERC and

representatives from the minerals industry. It is important to recognize that the concept of a research chair may include several individuals. Such a nucleus of personnel devoted to a specific line of inquiry can be enormously productive.

3. Substantially Increased Investment in R&D

Efforts must be made to increase the resources applied to mining, minerals and metals R&D in British Columbia. This increased support must come from all those involved with the industry. The Science Council of B.C. can take the lead in this matter by substantially increasing its level of funding through the Mines, Minerals and Metals Grant Selection Committee. Industry and government can also be encouraged to support specific projects with continuing funds.

4. Centres of Advanced Technology for Mining, Minerals and Metals Research

MITEC has proposed the establishment of a number of specialized research centres across the country as a means of promoting and expanding research and development that will be beneficial to the Canadian mining, minerals and metals industry. This committee strongly supports MITEC's concept of regional centres of expertise in emerging technologies and recognizes the need for and benefits of such centres in British Columbia.

Proposals are now being prepared for several centres with relation to the B.C. mining, minerals and metals industry.

1. A centre for advanced technology in remote sensing, (has relation to the industry through the potential application to mineral exploration).

2. A centre for advanced technology for rare and precious metal resources (clearly includes a diversity of undertakings of interest to the entire spectrum of the industry).

3. A centre for advanced materials (has been proposed to the provincial government from UBC).

Recent publicity by the federal government indicates that federal funding will be forthcoming for such centres in the near future. The Science Council of B.C. should maintain an informed awareness of progress in this matter and endeavour to support worthy proposals that will have a significant positive influence on R&D in British Columbia.

VII NEXT STEPS

In order to implement these recommendations, the following steps are required:

1. Progressively through the management committee and larger forums of the Mining Association of B.C. (including its annual meeting on February 26) and the B.C. and Yukon Chamber of Mines test the support for these recommendations and seek funding for the R&D coordinator.

2. Seek cooperation from and coordination with the provincial government, Science Council of B.C., MITEC, Coal Association of Canada, CANMET, the universities, the Mining Association of B.C. and the Mining Suppliers, Consultants and Contractors Association of B.C. on the proposals in this report.

3. Complete the funding arrangements and reporting relationship of the R&D coordinator. Appoint an individual with the mandate and budget.

4. Request support for industry/research chairs.

5. Gather support for centres of excellence.

6. Have the R&D coordinator develop a plan for R&D in B.C., start a network of coordination and information and provide an interface with national organizations involved with R&D.

SUMMARY OF RECOMMENDATIONS

FROM ALL SECTORS

AGRICULTURE AND FOOD PROCESSING

PRIMARY AGRICULTURE
- ROLE OF AGRICULTURE CANADA
- VERY SMALL AVAILABLE LAND BASE

SECONDARY MANUFACTURE
- POTENTIAL GROWTH AREA

FOOD PROCESSING
- POTENTIAL GROWTH AREA

RECOMMENDATIONS

- INTERFACE WITH BIOTECHNOLOGY
  - DISEASE CONTROL
  - GENETICS
  - WASTE MANAGEMENT
- VALUE ADDED
  - FOOD PROCESSING
- INCREASE PRODUCTIVITY
- INCREASE INDUSTRY INVOLVEMENT
  - CO-OPERATIVE RESEARCH

AGRICULTURE AND FOOD PROCESSING

RECOMMENDATIONS (CONT'D.)

- FUNDING FOR SECONDARY MANUFACTURE, FOOD PROCESSING
- RESEARCH ORGANIZATIONS STAFFING AND EQUIPMENT
- GENERAL AWARENESS
- TECHNOLOGY TRANSFER

AQUATIC RESOURCES

$750M INDUSTRY

AQUACULTURE - HIGH GROWTH
- SCIENCE ISSUES

RECOMMENDATIONS

- WATER QUALITY
  - SPECIFIC CONTAMINANTS
  - AQUACULTURE
- AQUATIC INSTRUMENTS AND DEVICES
  - INTERFACE WITH SECTOR
  - GROWTH AREA
- FISH HARVESTING
  - GOVERNMENT AND SOCIAL POLICIES
  - IMPROVEMENTS POSSIBLE
  - SHIP/SHORE COMMUNICATION

AQUATIC RESOURCES

RECOMMENDATIONS (CONT'D.)

- FISH PROCESSING
  - NEW PRODUCTS
  - BY-PRODUCTS
  - QUALITY
  - PACKAGING
- AQUACULTURE
  - INTERFACE WITH BIOTECHNOLOGY
    - DISEASE CONTROL
    - NUTRITION
    - GENETICS
    - WASTE MANAGEMENT
  - NETWORK OF EXCELLENCE

BIOTECHNOLOGY

EMERGING INDUSTRY - $12M

IMPACTS ON MANY SECTORS - FORESTS
- AGRICULTURE
- AQUACULTURE
- HEALTH
- WASTE MANAGEMENT
- MINING

NEED FOR STRATEGIC PLANNING, CO-ORDINATION

RECOMMENDATIONS

- FOCUS ON
  - DISEASE CONTROL
  - GENETIC IMPROVEMENT
  - WASTE MANAGEMENT

- STRATEGIC PLANNING - USE OF EXISTING COMMITTEE

- LONG TERM COMMITMENT OF FUNDING

- RAISE FUNDING FROM $10M TO $30M - 5-10 YEARS

BIOTECHNOLOGY

RECOMMENDATIONS (CONT'D.)

- STRATEGIC RESEARCH, TRAINING, SCHOLARSHIPS
- INDUSTRY/UNIVERSITIES INTERACTION
- REVIEW FACILITIES NEEDS AND CO-ORDINATION

ENERGY

MAJOR RESOURCE OF PROVINCE

DEPENDENCE OF OTHER RESOURCE SECTORS

OIL - IMPORT TO B.C.

NATURAL GAS SURPLUS

RECOMMENDATIONS

- OIL & GAS
  - DEVELOP UNDERSEA ROBOTICS
  - PREPARE FOR SWITCH AWAY FROM OIL
  - NATURAL GAS DIESEL ENGINE CONVERSION
- COAL
  - DEVELOP CAPABILITY TO ANALYZE COALS
  - BENEFICIATION & TRANSPORTATION
  - ALTERNATIVE USES

ENERGY

RECOMMENDATIONS (CONT'D.)

- WOOD RESIDUE AND BIOMASS
  - CONTINUE DEVELOPMENTS - METHANOL, ETHANOL
- OTHERS
  - HYDROGEN
  - FUEL CELL

SCIENCE & TECHNOLOGY ENERGY FOCUS

- CENTRE FOR ENERGY STUDIES
- BUILD EXPERTISE
- UNDERTAKE TESTS
- NATURAL GAS
- LONGER TERM ITEMS

FORESTS AND FOREST PRODUCTS

GROWTH AREA

MOVING TO VALUE ADDED PRODUCTS

RESOURCE DIMINISHING AND MORE EXPENSIVE

WORLD-WIDE COMPETITION

DEPENDENCE ON SCIENCE & TECHNOLOGY

ADVANCED MACHINERY AND SYSTEMS

PEOPLE NEEDS

RECOMMENDATIONS

- OVERALL CO-ORDINATION FOR SCIENCE AND TECHNOLOGY
- ADD VALUE
- IMPROVE PRODUCTION FOR RESOURCE

FORESTS AND FOREST PRODUCTS

RECOMMENDATIONS (CONT'D.)

- RAISE TECHNOLOGICAL AWARENESS AND COMPETENCE
  - RESEARCHERS
  - 'RECEPTORS'
- TECHNOLOGY TRANSFER
- USE OF ADVANCED SYSTEMS, TECHNOLOGIES AND MACHINERY

INFORMATION TECHNOLOGY

$1 BILLION INDUSTRY

11,500 PEOPLE

25%-50% ANNUAL GROWTH

RESOURCE INDUSTRIES/INFORMATION TECHNOLOGY

PEOPLE NEEDS

CO-ORDINATED ACTIONS

RECOMMENDATIONS

- ENHANCE RESOURCE INDUSTRIES BY ENHANCING THE INFORMATION TECHNOLOGY INDUSTRIES
- COMMIT TO INFORMATION TECHNOLOGY
- MARKETING, MANAGEMENT, TECHNICAL PEOPLE
- CO-ORDINATION AND PLANNING ROLE
- INFRASTRUCTURE AND SUPPORT

MANUFACTURING

IMPORTANCE TO PROVINCE

4,000 COMPANIES - 40 LARGE

LACK OF TRAINING

DIFFICULTIES OF LOCATING PARTNERS

TECHNOLOGY TRANSFER - SMALL COMPANIES

RECOMMENDATIONS

- STRATEGIC PLAN - 'CHAMPION'
- BIOMEDICAL DEVICES
- EDUCATION AND TRAINING
- TECHNOLOGY CENTRE
- RESOURCE INDUSTRIES - ROBOTICS
- NETWORKING
- CAD/CAM
- FUNDING

MINING, MINERALS, METALS

NEEDS

- INDUSTRY INVOLVEMENT
- NATIONAL CO-ORDINATION
- FOCUS ON R&D
- RAISING AWARENESS

RECOMMENDATIONS

- R&D CO-ORDINATOR FOCUSSED ON B.C. NEEDS, NATIONAL INTERFACE

- INDUSTRY CHAIRS - ADVANCED MATERIALS

- CENTRES OF EXCELLENCE:

  - ADVANCED MATERIALS
  - INDUSTRIAL MINERALS
  - GEOLOGICAL EXPLORATION
  - RARE & PRECIOUS METALS

EMERGING THEMES

- BUILD ON EXISTING COMPANIES, ORGANIZATIONS AND INDIVIDUALS
- ORGANIZED STIMULATION OF INTERACTION AND PLANNING WITHIN AND BETWEEN SECTORS
- RESOURCE INDUSTRY FOCUSSED, TECHNOLOGY DRIVEN CENTRES OF EXCELLENCE
- VALUE ADDED PRODUCTS FROM RESOURCES USING TECHNOLOGY DEVELOPED IN B.C.
- DEVELOP THE MARKETING, MANAGEMENT AND TECHNICAL TALENTS OF OUR PEOPLE
- EFFECTIVE USE OF SIGNIFICANTLY MORE R&D SPENDING